Water Resources Assessment and Research Subactivity

Program	1999 Estimate	Uncontrol. & Related Chgs	Program	Program Changes	FY 2000 Budget Request	Change from 1999
Ground-Water Resources	3,170	96	-851	0	2,415	-755
National Water-Quality Assessment	71,593	2,165	-12,532	0	61,226	-10,367
Toxic Substances Hydrology	14,659	433	-3,284	474	12,282	-2,377
Hydrologic Research & Development	**15,011**	**450**	**-2,786**	**-300**	**12,375**	**-2,636**
Total Requirements $000	104,433	3,144	-19,453	174	88,298	-16,135

Note: The Program Redirect column reflects the redirection of funds to the Integrated Science, Science Support, and Facilities activities.

Hydrologic Research and Development

Current Program Highlights

The Hydrologic Research and Development Program focuses on long-term investigations that integrate hydrological, geological, chemical, climatic, and biological information related to water resources issues. The program facilitates the development of new fundamental knowledge about the processes affecting water and encourages the development of new methods and interpretive techniques to aid in data collection, synthesis, and understanding. Its long-term interdisciplinary approach allows work on large, difficult hydrologic problems, and the direct linkage of the program with other USGS water-resources programs ensures that the research remains relevant to water-resources needs. The new knowledge, tools, and insight needed to solve hydrologic problems are gained through three approaches: Individual Studies, Large Interdisciplinary Studies, and the Development of Tools and Methods.

Individual Studies — Those receiving current emphasis include studies directed towards gaining an understanding of the:

- environmental effects that fire has on watersheds, focusing on post-fire hydrogeological impacts and ecological aspects of mitigating erosion,
- microbiologic processes that affect the quality of water,
- shape of river channels and the erosional processes governing the source, mobility, and deposition of sediment,
- movement of water through porous and fractured materials,

- movement of water and gases in the unsaturated zone above the water table,
- chemical and biochemical reactions affecting natural and contaminated water,
- accuracy and reliability of computer models,
- interaction of ground water and surface water in key areas such as wetlands,
- processes and factors (such as land use) that govern the sources, sinks, and transport of carbon and nitrogen,
- risk of inundation from a tsunami in Puget Sound using a recently developed USGS tsunami model, and
- effect of subsidence on wetland habitat loss and as a threat to low-lying population centers in Louisiana.

Large Interdisciplinary Studies — Research conducted primarily through large interdisciplinary studies is currently focused in the following areas:

- Hypoxia causes. Hypoxia, a low oxygen condition in water, is known to be related to high levels of nitrogen and its associated algae blooms. While scientists believe hypoxia in the Gulf of Mexico is related to nitrogen from the Mississippi River and its tributaries, it is unclear to what extent various sources of nitrogen contribute to the hypoxia problem. A new USGS research study will focus on nitrogen transformations, examining the geochemistry, microbiology, and transport of nitrogen species in parts of the Mississippi River Basin. This information is needed to determine how to effectively correct this critical National problem.

- Regional and global biogeochemical cycles (such as the carbon and nitrogen cycles) in rivers, lakes and reservoirs. Five water, energy, and biogeochemical budgets (WEBB) sites in Colorado, Wisconsin, Vermont, Georgia, and Puerto Rico, representing a range of hydrologic and climatic conditions, are providing a focal point for research into processes that control the exchange of water, energy, and carbon between the atmosphere and the land surface. Understanding these processes is critical to answering questions central to such important environmental policy issues as greenhouse gases, atmospheric deposition, nutrient enrichment, and biodiversity. In 1999, information that has been collected will be used in watershed modeling efforts that are designed to develop an understanding of small headwater areas, identify parameters necessary for scaling up to larger watersheds, and link chemical and hydrologic processes. Such efforts are critical to understanding how better to manage the Nation's waters.

- Basins and watersheds, where interactions occur among a variety of processes associated with carbon budgets, nutrient transport, land-water interactions, atmospheric chemistry, botany, and geochemistry. Lake studies, which examine how lakes integrate these and other hydrologic processes and preserve a record of past environmental change in their sediments, are centered on two lake watersheds in Minnesota: Williams Lake and Shingobee Lake. In addition, a Mississippi River basin study focused on carbon sources and sinks is examining nutrient, carbon, and sediment storage in lakes, reservoirs, and wetlands. This study will lead to a better understanding of the global carbon cycle and of how erosion and sedimentation are affected by land use changes.

- The Middle Rio Grande basin, where determination of recharge rates and ground-water flow paths will improve a computer model and will provide a better understanding of the

geohydrology of the Middle Rio Grande basin. A new technique using stream-surface temperatures is providing new insight into streambed infiltration and is being used to develop recharge estimates based on temperature profiles. This focused effort will help water managers plan for future development of water resources in the Albuquerque area, and is in direct support of the Middle Rio Grande study described in the Ground Water Resources Program.

Tools and Methods — Studies of water resources require the development and enhancement of new tools and methods such as:

- Developing new and refined hydrologic computer models that are relied on in the United States and throughout the world. Currently, an increased emphasis is being given to models that are directed towards coupling water movement, chemical transport, and geochemical reactions; adding model components that describe microbiological reactions; and developing interfaces between real-time data and the models. Also being developed is a two-dimensional surface-water flow modeling system that will allow the user to select from several flow computation computer programs, employing user friendly routines for input of channel geometry and boundary condition data.

- Enhancing existing computer models by making them more flexible and user friendly. This effort involves developing interfaces for easily adding a wide variety of data (e.g., topographic and hydrologic data) to models and developing ways to present the model results so that they can be easily understood.

- Developing and refining methods for determining the age of relatively recent ground water (using, for example, the presence of chlorofluorocarbons or sulfur hexafluoride) in order to identify and trace the movement of recently recharged ground water. These techniques help delineate well-head protection areas and predict the future improvements or degradation of ground water resources.

- Refining methods used in determining the nature of dissolved organic matter so that the techniques can be applied to assessing the potential risks of using reclaimed wastewater to recharge potable-water aquifers.

- Developing methods that will enhance the use of stable isotopes of oxygen, hydrogen, nitrogen, and sulfur in tracing hydrologic sources and pathways, biogeochemical processes, and residence times of waters and solutes.

Recent Accomplishments

Modeling Activities — The USGS continued to make major advances to its computer models, available for free electronic retrieval on the Internet (**http://water.usgs.gov/software**) and used throughout the world to simulate hydrologic processes. FY 1998 was notable for improvements made to three-dimensional ground-water flow and transport models, such as MOC3D, and for the further addition of easy-to-use graphical user interfaces (GUIs) to ground-water flow and transport models and to PHREEQC, a geochemical model. By providing immediate visualization of simulation results, the GUIs provide a better understanding of what

the data mean. Another advance was the development of a new computer code, UCODE, which is designed to be universally applicable to any model that uses or produces data in an ASCII or text-only format. UCODE, which can be used to manipulate model-input values and to evaluate the model results, was developed by the USGS and the Colorado School of Mines in cooperation with the U.S. Army Corps of Engineers, and is being maintained by the Colorado School of Mines.

Nitrate contamination — A method was developed that uses denitrifying bacteria to treat nitrate-contaminated drinking water supplies. It utilizes native ground-water bacteria to remove nitrate from water supplies in a flow-through bioreactor and is specifically oriented to small-scale water supply users (for instance, a household, farm, or small business). This invention may be useful for improving the quality of small scale, individual drinking water supplies. Such water supplies predominate in rural America and are the type of water most susceptible to nonpoint-source nitrate contamination.

Watersheds and weathering — A recent USGS watershed study in Puerto Rico's Luquillo mountains found that the watershed has the fastest documented weathering rate of silicate rocks on the Earth's surface, at about an order of magnitude faster than the global average. Three independently determined sets of data indicate that precipitation, temperature, and vegetation changes during the past several hundred thousand years do not appear to have significantly affected the weathering rate. Knowledge of weathering is critical since it is a crucial process by which compounds that are depleted by land use practices, including deforestation and agriculture, are replaced, and is the principal process by which acid precipitation is neutralized in soils and ground water. The Luquillo study is of particular interest because relatively little is known about weathering processes in upland tropical watersheds.

Carbon Studies — A 1998 publication presents results from a USGS study which indicate that a significant amount of carbon is stored in sediments that are deposited in lakes, reservoirs, wetlands, flood plains, etc., and thus does not reach the ocean. Studies on greenhouse gases had previously recognized that there is an imbalance between the amount of carbon believed emitted to the atmosphere from human activities and the amount that has been found in the ocean, atmosphere, and on land. This study points to terrestrial sedimentation as the likely sink for the "missing carbon" and suggests that a major redesign of how the carbon cycle is modeled will be necessary.

San Francisco Bay — As part of its continuing long-term investigations in San Francisco Bay, the USGS now provides both real-time information and historical data related to its research on the Internet. For example, a USGS web site (**http://sfbay.wr.usgs.gov/access/wqdata**) which provides up-to-date water quality data, as well as 30 years of historical data, is being used by public schools and university classes and in teacher workshops. Results from one recent Bay study indicate that the equivalent of about 60 percent of the total annual input of cadmium, nickel, and zinc from local waste-water treatment plants to South San Francisco Bay is cycled through phytoplankton that bloom there each spring. Although copper, which was also measured, was not similarly affected, the results suggest that processes (such as nutrient enrichment) affecting phytoplankton bloom frequency and intensity in estuaries may also affect trace metals, and that estuarine sampling designs and contaminant monitoring programs must consider the effects of phytoplankton on trace metals.

Drought and Deluge — A recent study of the north-central U.S. indicates that the recent drought (1988-1992) was as severe as previous droughts of the 20th century and that the subsequent deluge (1993-present) may be the wettest period during the past 500 years. In making this analysis, USGS scientists relied on long-term data records, including a 95-year old record of streamflow and a 150-year record of stage of Devils Lake in North Dakota. Scientists then used fossil records from Devils Lake sediments to extend the record back 500 years. This information is being used to predict the effects of climate change on ground-water recharge, water chemistry, wetland vegetation and wildlife habitat in prairie pothole wetlands.

Radioactive waste — The USGS recently completed a study that examines the transport of gases in Yucca Mountain, Nevada, site of the potential high-level radioactive waste repository being evaluated by the Department of Energy. This will likely prove to be the definitive study of chemical and physical gas-transport processes that occur at the site. The study describes the origin, reactions, and transport phenomena that govern gas distribution; this information is essential to evaluating the sources, transport, and possible release of volatile compounds at Yucca Mountain. The study also provides a basic understanding of the transport and reaction of gases in the unsaturated zone of fractured rock and similar topographies. The study found that gas flow in the mountain has been altered by a well drilled through a rock layer that normally acts as a barrier to gas flow; this suggests that more extensive venting across this layer through open boreholes (if they exist) under a repository heat loading seems likely.

Justification for Program Change

	FY 2000 Request	Program Change
$(000)	12,375	-300

New efforts to examine the effect of subsidence on wetland habitat and low-lying urban areas in Louisiana will be curtailed. Research efforts begun in 1999 focusing on hypoxia causes in the Gulf of Mexico will continue through a $400,000 increase requested in the Hydrologic Networks and Analysis program. In 1999, hypoxia research efforts are primarily related to denitrification processes in surface water, ground water, and soils in the Mississippi River Basin since a better understanding of denitrification is believed to be critical to mitigating hypoxia in the Gulf. In particular, the new research effort is focused on looking at the difference in denitrification rates during low and high flow conditions, the effect of ground water on in-stream nitrogen concentrations, and how the availability of carbon in different carbon compounds may influence denitrification.